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Some Methods for Assessing the Activity of Soil Animals in the Breakdown of Leaves

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With 7 figures in the text

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1. Introduction

The role of soil animals in the breakdown of organic matter in the soil is often discussed, but quantitative evidence that soil animals cause breakdown is meagre. The size of soil animal populations, in numbers and biomass (the weight or volume of the animal population) is frequently cited as evidence that these populations are important (MURPHY 1955). Biomass is further used to calculate total respiration rates of the population to indicate the amount of animal activity (NEF 1957), and BERTHET (1963) has measured respiration rate of oribatid mite populations directly, though MELLANBY (1960) doubted the value of respiration rates as an index of biological activity.

Change in weight of samples of leaves with time has also been used as a measure of the activity of soil animals causing leaf breakdown. For instance BOCOCK and GILBERT (1957) measured changes in weight of leaf litter samples kept, for ease of handling and recovery, in the litter layer in nylon nets. Such methods have the disadvantage that once samples are dried and weighed they cannot be replaced and later re-examined, and they do not differentiate between loss of tissue caused by soil animals and that caused by bacteria and fungi. EDWARDS and HEATH (1963) assessed the time taken for total breakdown of leaf tissue, by observing when leaf discs on the soil surface were first fragmented and when they finally disappeared, but this did not measure the intermediate rates of breakdown. In our work the actual amount of leaf lamina eaten was estimated by visual and photometric methods, already briefly described (EDWARDS and HEATH 1963), which allow repeated examination of the same samples and some assessment of the relative importance of animals, bacteria and fungi in breaking down leaf tissue.

2. Methods

All the experiments measured the disappearance of standard leaf discs, 2.5 cms in diameter. Discs were cut from leaves either with a cork borer or with a special apparatus (Fig. 1) made from a modified potato slicer with a hardened 2.5 cm. steel tube mounted on its base. Stacks of leaves, supported on a spring-mounted platform, were pressed down on to the tube by a hard rubber pad mounted on the arm. The discs are cut and fall into a small drawer in the base. Discs were placed either in the litter layer or in the soil, where animals could feed on them. They were removed periodically, taken to the laboratory and laid between plates of glass so that the percentage disappearance could be estimated visually when these were held up to the light. The amount eaten was at first estimated by eye for each disc in turn using a small perspex grid, but this was tedious and equally good results were obtained by subjective visual estimates, after a little practice. A leaf-area photometer (from a design by Evans Electroselenium Ltd.) (Fig. 2) was made and is now used to measure the leaf area of a batch of discs photo-electrically. The instrument can measure the area of batches of 5 to 100 discs simultaneously, provided black masks are used to decrease the measuring area for the smaller number of discs.

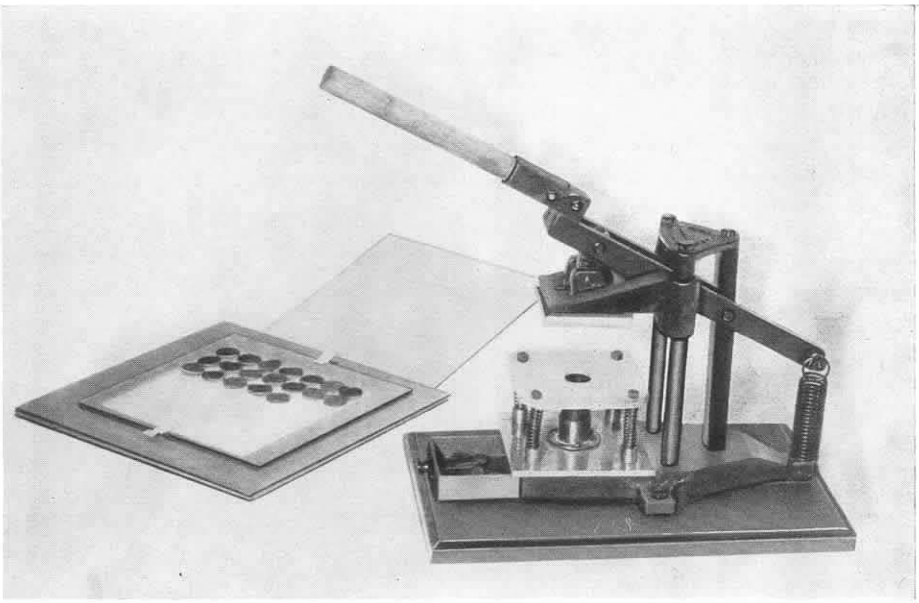

Fig. 1. Apparatus for cutting leaf discs.

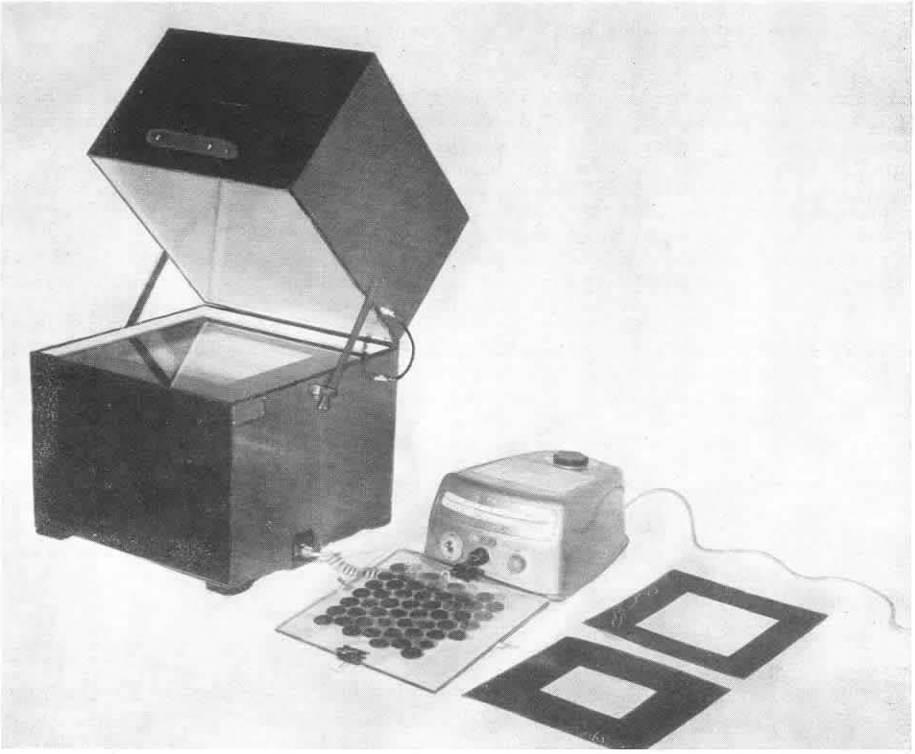

Fig. 2. Leaf area photometer.

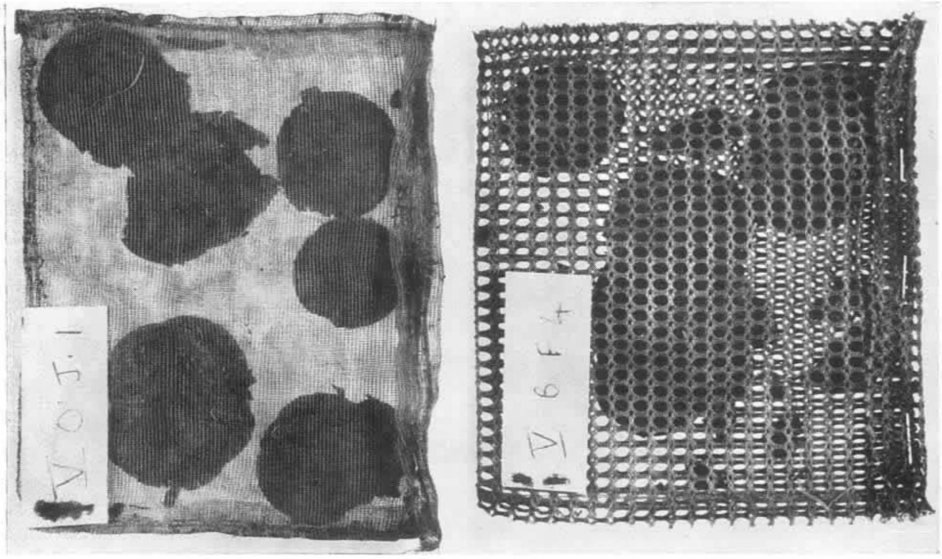

Fig. 3. Leaf discs in nylon mesh bags.

The experiments were at three different sites with similar soil types; a naturally regenerated oak-dominant wood, approximately 60 years old; a beech plantation approximately 20 years old; and a 200 years old pasture now kept continuously fallow.

Two methods of studying the progress of decomposition were used. In woodland sites the leaf litter was removed, discs laid on the soil surface of plots, which were then covered with terylene net of 1 mm. mesh and the leaf litter replaced on the net. Earthworms were kept out of some plots by a second layer of terylene net (1 mm. mesh) placed about 5 cm. below the soil surface, the earthworms and cocoons having first been removed by hand from this upper layer of soil before it was replaced. The plots were divided into equal sections and sets of 20 disc samples were set out and later collected from different sections at regular intervals, unless any had been removed by worms or other animals. The amounts of tissue that had disappeared were estimated visually and the samples were then oven-dried at 80 °C and weighed.

In the other method batches of 50 discs were placed in nylon mesh bags measuring 10 × 7 cm. (Fig. 3). Three mesh sizes were used; one of fine mesh, spun-nylon material with openings of 0.003 mm. so that micro-organisms only can enter; one of fine mesh monofilament nylon with openings of about 0.5 mm., which allows the small soil animals to enter, but excludes earthworms; and a third of coarse-mesh spun-nylon material with openings of about 7 mm., through which all soil invertebrates including earthworms can enter to feed, but which prevents worms from pulling discs out. The bags were sewn round three sides and closed by folding and stapling the fourth side. They were buried beneath the top 2.5 cm. of soil and dug up every 2 months, the discs removed and the amount that had disappeared estimated visually or photometrically in the laboratory, before they were buried again. Care was necessary to ensure that discs did not dry and they were kept in polythene bags in a refrigerator before and after examination.

Succulent green leaf material, such as lettuce, bean or beet disappears so rapidly that it must be examined weekly. Such frequent handling can cause damage, so these tissues were placed in a single layer of 25 discs in fine mesh bags about 14 cm. square. The discs could then be examined through the mesh without opening the bags, provided they were handled carefully to avoid displacing the discs in the bag.

3. Results and Discussion

A standard form of leaf tissue must be used in the studies described here because leaves from different trees of the same species, or even from different parts of the same tree, disappear at very different rates in the same soil. When green and apparently similar discs were placed in the soil or litter some remained entire and eventually became dark brown, whereas others were still greenish and very fragmented. The greenish discs were usually thinner than the brown ones and it is suspected that they are from the more shaded parts of the tree. In one woodland experiment where the disappearance of thick and thin leaves was compared, after nine months all the thin discs had disappeared whereas many of the thick discs remained untouched.

The mesh size used to isolate the leaf discs from the soil animals can be chosen roughly to control the sizes, and hence the kinds, of animals feeding on them. Further evidence indicating which animals are responsible for the feeding can be obtained by carefully examining the discs for animals when they are laid on the glass sheets to estimate the amount of breakdown.

When oak and beech discs were put into bags of very fine mesh (0.003 mm.), which completely excluded soil animals, the leaf discs showed little apparent breakdown in one season. The micro-organisms probably cannot disintegrate the harder kinds of leaf until the animals have first fragmented them.

The disadvantages of weighing to estimate disappearance of leaf tissue were outlined in the introduction. The disappearance of samples of oak and beech leaf discs estimated visually and by weighing is related in Tables 1 and 2 and Fig. 4. There was a close direct relationship between the two methods of estimation when the results from 11 consecutive sampling dates were considered. A separate similar regression line could be calculated for each sampling date and each type of leaf and, from these, separate estimates of the original weight of the samples. Plotting these estimated original weights against sampling dates showed that at the sampling period, the estimate of the original weight did not differ significantly from that at the beginning. The regressions calculated for estimated original weight against sample date were $\bar{x}_0 = 1.05 - 0.00083 (\pm 0.0072)\ \bar{x}_1$ for oak and $\bar{x}_0 = 1.18 + 0.01148 (\pm 0.01725)\ \bar{x}_1$

Table 1 Comparison of Oak Leaf Disappearance by Weighing and Visual Methods

Sample No.	Dry wt (gms/sample) I	II	III	IV	Mean	% original mean wt	% disappearance by weight	% visual disappearance
1	0.64	0.84	0.96	1.21	0.91	86.6	13.4	13.5
2	0.51	0.86	1.03	1.14	0.89	84.7	15.3	14.6
3	0.50	0.55	0.76	0.89	0.68	64.7	35.3	30.0
4	0.19	0.44	0.71	0.67	0.50	47.6	52.4	55.3
5	0.41	0.24	0.86	0.78	0.57	54.3	45.7	47.6
6	0.10	0.10	0.69	0.83	0.43	40.9	59.1	60.7
7	0.26	0.15	0.63	0.33	0.34	32.4	67.6	64.8
8	0.14	0	0.20	0.30	0.16	15.2	84.8	84.3
9	0.05	0	0.20	0.13	0.10	9.5	90.5	90.6
10	0	0	0	0	0	—	—	100.0

Table 2 Comparison of Beech Leaf Disappearance by Weighing and Visual Methods

Sample No.	Dry wt (gms/sample) I	II	III	IV	Mean	% original mean wt	% disappearance by weight	% visual disappearance
1	1.19	1.12	1.10	1.17	1.15	100.0	0	4.2
2	1.12	1.18	1.10	0.92	1.08	92.9	6.1	4.5
3	1.13	0.97	1.05	0.42	0.89	77.3	22.7	9.9
4	0.97	0.88	1.14	1.21	1.05	91.3	8.7	18.3
5	0.90	0.87	1.15	0.90	0.96	83.4	16.6	23.8
6	0.85	0.89	0.81	0.40	0.74	64.3	35.7	33.6
7	0.56	0.44	0.71	0.43	0.54	46.9	53.1	47.5
8	0.59	0.47	0.69	0.84	0.65	56.5	43.5	39.6
9	0.40	0.27	0.64	0.79	0.53	46.0	54.0	56.9
10	0.38	0.68	0.71	0.65	0.61	53.0	47.0	57.5
11	0.09	0	0.28	0.22	0.15	13.0	87.0	89.1

for beech. Therefore the loss of weight calculated as a percentage of the original weight could be plotted against the visual estimate of the percentage of original leaf area that had disappeared (Fig. 5).

The relationship was close, so that visual methods can be used as an alternative to weighing. The discrepancies between results from the two methods were greatest when there was little fragmentation and loss of weight, and were less for oak than for beech, probably because feeding on beech produces tiny holes difficult to estimate by eye. It is surprising that the points lie close to a straight line at 45°, because if activity by micro-organisms caused loss of weight without any change in appearance of the leaf, the relationship would be curvilinear and lying above the line. A line of the form seen indicates that disappearance was mostly caused by animal activity. This agrees with earlier observations (Edwards and Heath 1963) that samples of litter undamaged by animals showed no significant decrease in weight per unit area during twelve months.

Fig. 6, which is a typical breakdown curve for a hard leaf tissue, estimated by visual methods, shows three phases; the first of slow disappearance before the tissue became acceptable to animals, an intermediate one where it disappears rapidly and a final slow rate of disintegration of the unpalatable remains.

In the experiments where leaf areas were estimated visually, two main methods of exposing leaf discs to feeding by soil animals were used. Discs were either laid on the soil surface between nylon netting, and similar samples taken periodically, or enclosed in nylon bags and buried, when the discs were taken out to be examined at regular intervals and buried again. The first method has the disadvantage that, when the leaves become fragmen-

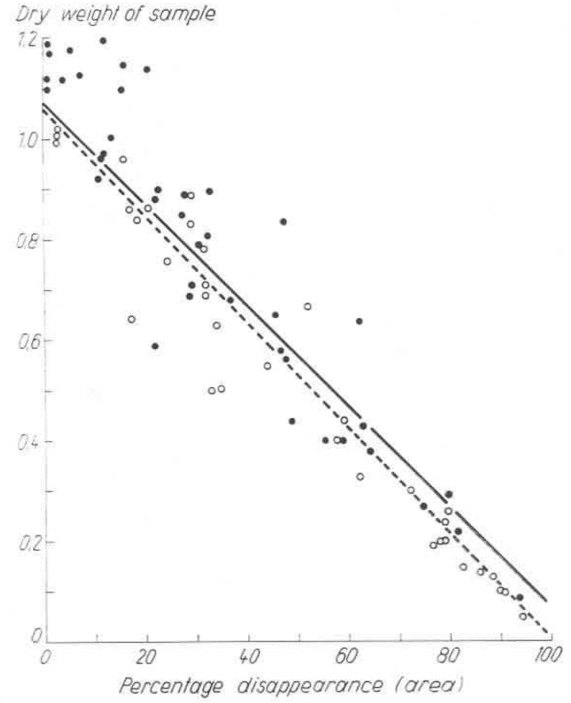

Fig. 4. Regression of dry weight of sample on per cent disappearance.
●———● Beech (total fauna) $\bar{x}_0 = 1.067 - 0.01021\ (\pm\ 0.00081)\ \bar{x}_1$
○— — —○ Oak (total fauna) $\bar{x}_0 = 1.055 - 0.01062\ (\pm\ 0.00031)\ \bar{x}_1$

ted, it is difficult to know whether the pieces have come from one or more discs. This error can be eliminated by laying discs out in small groups or areas, each of which constitutes a sample. Another drawback to the first method is that continual sampling gradually lessens

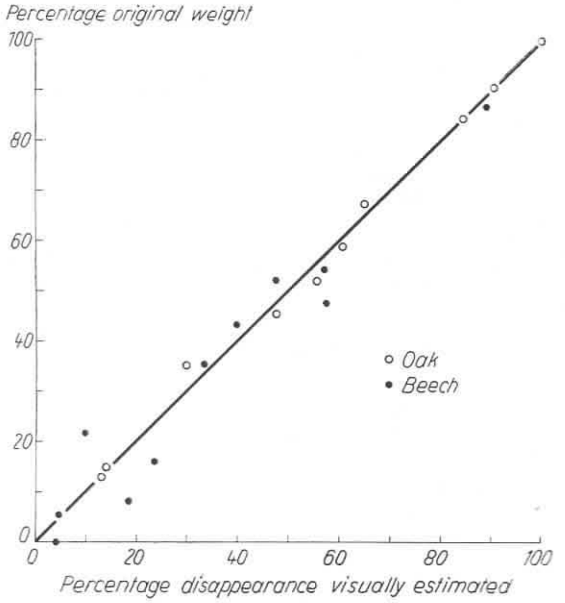

Fig. 5. Relationship between per cent of original weight and per cent disappearance.
● Oak
○ Beech

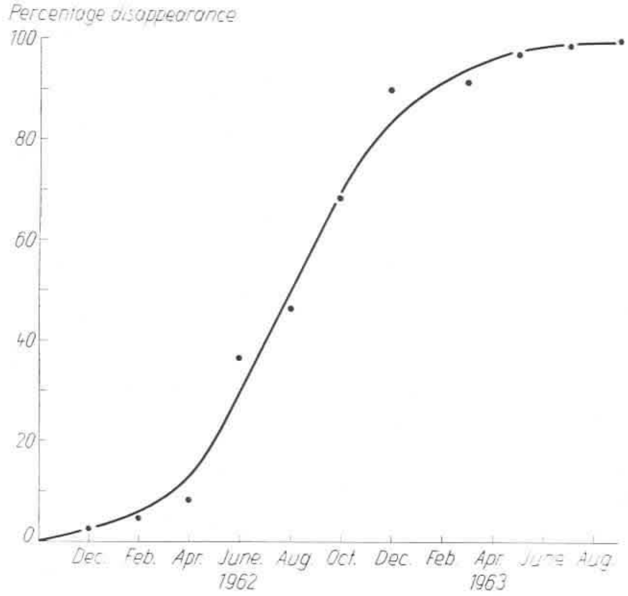

Fig. 6. Breakdown of beech leaf discs in nylon mesh bags.

the number of discs on which soil animals can feed, this can be overcome only by using very many more discs than required for samples. A criticism of the second method is that frequent handling of the same discs damages them and they may become dry and brittle, but with care this can usually be avoided. Results have indicated that the nylon bag method is generally preferable.

The visual estimation of leaf disappearance can be laborious and has now largely been replaced by photometer measurements, except for fragile leaf tissue which must be examined within the nylon bags. Fig. 7 gives the relationship between visual estimates and photometer measurements and shows that visual estimates are usually slightly larger than photometer measurements. When less than 10% of the tissue has disappeared, however, photometer measurements are consistently ~~smaller~~ larger than those made by eye, probably because the size of small holes is difficult to assess.

Estimating leaf disappearance by visual and photometric methods and relating this to faunal counts of biomass and laboratory feeding experiments may add considerably to the knowledge of the importance of the soil fauna in maintaining soil fertility.

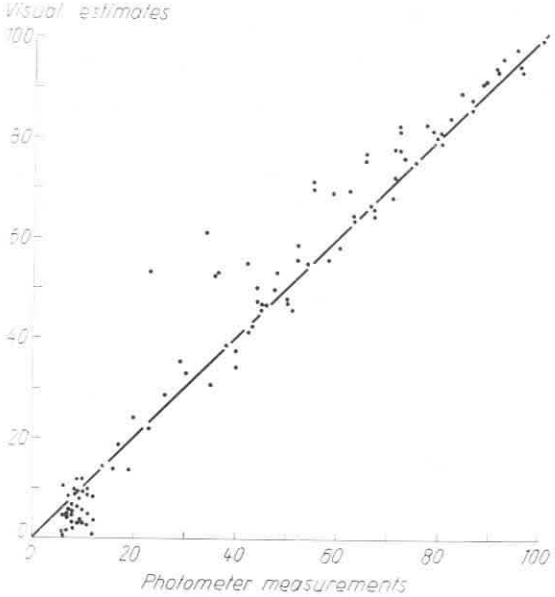

Fig. 7. Relationship between visual estimates and photometer measurements.

4. Summary

Visual and photometric methods for assessing the disappearance of leaf tissue buried in nylon mesh bags are described. They are rapid, accurate and satisfactory for determining the importance of different groups of soil animals in causing leaf breakdown. Estimates of the disappearance of the same leaf samples made by eye, photometrically and by weighing agree well. By using different mesh sizes the importance of different groups of animals or micro-organisms in leaf breakdown can be investigated separately. Leaf discs 2.5 cm. in diameter taken from the same part of a single tree were used as standard material.

4. Zusammenfassung

Es werden visuelle und photometrische Methoden zur Ermittlung des Rotteschwundes von Blattgeweben beschrieben. Das Blattgewebe wird, in Nylonbeutel verpackt, eingegraben.

Die Bestimmung der Bedeutung von verschiedenen Bodentiergruppen für den Blattabbau ist mit Hilfe dieser Methoden schnell, genau und in befriedigendem Maße möglich.

Visuelle und photometrische Schätzungen des Rotteschwundes von gleichen Blattproben stimmen gut überein.

Durch Verwendung von Nylongeweben verschiedener Maschenweite kann die Bedeutung verschiedener Tier- und Mikroorganismengruppen getrennt untersucht werden.

Blattscheiben mit einem Durchmesser von 2,5 cm, vom gleichen Teil eines einzigen Baumes, wurden als Standardmaterial verwendet.

5. Acknowledgements

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6. References

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